Evaluation of Management Tools for Fusarium Wilt of Lettuce in 2004

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Abstract

Fusarium wilt of lettuce was first recognized in Arizona in 2001. Since this first discovery, the pathogen, Fusarium oxysporum f.sp. lactucae (Fol), has been recovered from infected lettuce plants from approximately 30 different fields. This fungus is a soil-borne pathogen that can remain viable in soil for many years. Cultural disease control measures, such as extended soil flooding and soil solarization, have shown promise in managing Fusarium wilt in other cropping systems. The specific objectives of this research were to repeat preliminary soil solarization and flooding experiments conducted last year and to evaluate the effect of preplant treatment of planting beds with either Vapam or soil solarization on the subsequent incidence of Fusarium wilt on lettuce. In a microplot study, soil naturally infested with Fol was flooded or solarized for 15, 30, 45 and 60 days, then bioassayed by transplanting and growing lettuce plants in samples of treated soil as well as nontreated soil. In field studies, plots were solarized for 40 days or treated with Vapam before planting to lettuce. In the microplot experiment, the severity of Fusarium wilt on lettuce grown in previously flooded or solarized soil was significantly less than that in nontreated soil. Additionally, there was no difference between flooding and solarization with respect to disease severity, as lettuce plants in both cases had virtually no symptoms of Fusarium wilt. Weight of the tops of lettuce plants was significantly greater for plants grown in flooded or solarized soil compared to that in nontreated soil. Furthermore, top growth in solarized soil was sometimes significantly greater than that in flooded soil. Compared to nontreated soil, root growth in solarized soil was significantly greater. In contrast, root growth in flooded soil was not significantly different than that recorded in nontreated soil. In the field studies, the incidence of lettuce plants with foliar symptoms of Fusarium wilt was reduced by an average of 42% when grown on solarized beds compared to nonsolarized beds. Preplant application of Vapam at rates of 30, 45 and 60 gal of product per acre resulted in reductions in the incidence of Fusarium wilt of 38, 50, and 45%, respectively. Further work is needed to attempt to increase the

reduction of disease recorded this past year. Refinements in our solarization technique as well as application methods for Vapam may increase the efficacy of these tools in reducing the incidence and severity of Fusarium wilt of lettuce.

Introduction

Fusarium wilt of lettuce was first recognized in Arizona in 2001. Since this first discovery, the pathogen, *Fusarium oxysporum* f.sp. *lactucae* (*Fol*), has been recovered from infected lettuce plants from approximately 30 different fields. This fungus is a soil-borne pathogen that can remain viable in soil for many years. Development of disease management strategies for Fusarium wilt will be a formidable challenge. Historically, Fusarium wilt on crops other than lettuce, such as tomatoes and melons, has been successfully managed by developing and planting cultivars resistant to the fungal pathogen. In the long term, development of lettuce cultivars with resistance to (*Fol*) would be highly desirable. As the development of such resistant cultivars may take considerable time, more immediate disease management tools are needed.

Cultural disease control measures, such as extended soil flooding and soil solarization, have shown promise in managing Fusarium wilt in other cropping systems. A preliminary evaluation of soil flooding and soil solarization on subsequent activity of (*Fol*) was examined in 2003. Naturally infested soil was placed in containers (5-gallon buckets) that were buried in a field at the Yuma Mesa Agricultural Center so that the upper lip of each bucket was level with the soil surface. In the soil saturation trial, the soil in the buckets was maintained in a saturated state (flooded) for 15, 30, 45 or 60 days, then bioassayed for the presence of Fusarium by sowing and growing lettuce plants within treated soil. For the soil solarization trial, soil in each bucket was thoroughly irrigated, covered with clear plastic for15, 30, 45 or 60 days, then bioassayed for the presence of *Fusarium oxysporum* f.sp. *lactucae*. The severity of foliar and root symptoms were significantly lower, whereas the fresh weight was significantly higher for lettuce plants grown in soil that was flooded or solarized, compared to plants grown in soil not subjected to these treatments.

The specific research objectives during the 2004-2005 growing season were to i) repeat the soil solarization and flooding experiment described above and to ii) evaluate the effect of preplant treatment of planting beds with either Vapam or soil solarization on the subsequent incidence of Fusarium wilt on lettuce.

Materials and Methods

Microplot and bioassay trial. Soil naturally infested with *F. oxysporum* f.sp. *lactucae* (*Fol*), from a commercial field in Wellton, AZ, was collected on Jul 13, 2004 and placed in containers (5-gallon buckets) that were buried in a field at the Yuma Mesa Agricultural Center so that the upper lip of each bucket was level with the soil surface. Each bucket was considered a replicate microplot. For the soil saturation trial, soil in microplot containers was maintained in a saturated state (flooded) for 15, 30, 45 or 60 days, then tested for the presence of (*Fol*) by sowing and growing lettuce plants in this soil. For the solarization trial, soil in microplot containers was thoroughly irrigated, covered with clear plastic for 15, 30, 45 or 60 days, then tested for the presence of (*Fol*) by sowing and growing lettuce plants in this soil. Five replicate microplots were established for each of the four flooding and four soil solarization periods. The control treatment was five replicate containers containing dry soil not covered with plastic or saturated with water. Soil temperature was recorded at a depth of 2 inches and 9 inches within microplots that were flooded, solarized or served as a control.

Lettuce (cultivar Lighthouse) was seeded in transplant trays containing cells (1.0 inch square at the top x 2.0 inches deep) filled with a potting mix. These trays were maintained in the greenhouse until seedling emergence, then moved outside for further seedling growth. Sixteen-fl. oz. containers were filled with soil from each microplot, two containers with soil from a depth of 1 to 3 inches and two containers with soil from a depth of 8 to 10 inches. When plants had four true leaves, a lettuce plant was transplanted into each 16 fl. oz. cup on Dec 24 and grown in the greenhouse. Plants were watered daily and fertilized weekly with Miracle Gro fertilizer. Hourly soil temperature in the cups was recorded The experiment was terminated Feb 25, 2005, at which time the following data was collected: foliar disease symptom rating, root disease symptom rating, and fresh weight of plant tops and roots.

Field trials. The effect of preplant treatment of planting beds with either soil solarization or Vapam was studied in a five-acre field in Wellton, AZ, previously cropped to lettuce during the 2003-04 season and naturally infested with (*Fol*). After the lettuce crop, wheat was grown in this field. After harvest, the wheat residue was incorporated into the soil and rough beds were prepared. After an irrigation, five 50-ft. lengths of bed were covered with clear plastic on Aug 3, 2004 and maintained until Sep 13. Five beds of the same length not covered with clear plastic served as controls. Soil temperature was recorded at a depth of 2 and 9 inches in beds covered with plastic as well as in beds without plastic. An additional furrow irrigation was performed Sep 1. On Sep 15, Vapam was shank-injected at three different rates (30, 45 and 60 gal./acre) into 50 ft. lengths of bed, with each rate replicated three times. Control beds were not treated with Vapam. All beds in the solarization and Vapam trials were planted to lettuce (cultivar Lighthouse) on Oct 5. The incidence of Fusarium wilt was recorded Dec 9 and again at plant maturity on Jan 14, 2005.

Results and Discussion

Microplot and bioassay trial. The range and mean of soil temperature values at the 2-inch depth for the duration of the soil treatment period (Jul 13 to Sep 10, 2004) were as follows: (i) nontreated soil: range, 68 to 131EF (20 to 55EC); mean 104EF (40EC); (ii) flooded soil: range, 68 to 107EF (20 to 42EC); mean 91EF (33EC); (iii) solarized soil: range, 71 to 142EF (22 to 61EC); mean 113EF (45EC). Field soil naturally infested with *Fusarium oxysporum* f. sp. *lactucae* was subjected to flooding or solarization for periods of 15, 30, 45 or 60 days. The final severity of disease and growth of plants on Feb 25, 2005 in soil subjected to these treatments is shown in Table 1. The severity of Fusarium wilt on lettuce grown in previously flooded or solarized soil was significantly less than that in nontreated soil. Additionally, there was no difference between flooding and solarization with respect to disease severity, as lettuce plants in both cases had virtually no symptoms of Fusarium wilt. Weight of the tops of lettuce plants was significantly greater for plants grown in flooded or solarized soil compared to that in nontreated soil. Furthermore, top growth in solarized soil was sometimes significantly greater than that in flooded soil. Compared to nontreated soil, root growth in solarized soil was significantly greater. In contrast, root growth in flooded soil was not significantly different than that recorded in nontreated soil. Flooding and solarization are known to change the composition of the microflora community in soils. Some of these organisms found in soils can be considered weak plant pathogens, which may cause subclinical (very low) levels of root damage and decay. The doubling of root mass in solarized soil compared to nontreated soil may in part be explained by the reduction in the population of these weak plant pathogens. Data from this study suggest that preplant solarization and flooding of soil may be able to significantly reduce the incidence and severity of Fusarium wilt of lettuce in infested fields. Furthermore, solarization may provide additional benefits by reducing populations of weak soil-borne plant pathogens, thus promoting overall increased lettuce plant growth and health.

Field trials. During the solarization treatment from Aug 3 to Sep 13, the range (and mean) of soil temperatures at a depth of 2 and 9 inches was 78 to 140EF (105EF) and 70 to 112EF (92EF), respectively. By comparison, in beds not covered with plastic, the range (and mean) of soil temperature at a depth of 2 and 9 inches was 82 to 115EF (97EF) and 71 to 105EF (90EF), respectively. The incidence of lettuce plants with foliar symptoms of Fusarium wilt was reduced by an average of 42% when grown on solarized beds compared to nonsolarized beds (Table 2). Preplant application of Vapam at rates of 30, 45 and 60 gal of product per acre resulted in reductions in the incidence of Fusarium wilt of 38, 50, and 45%, respectively. Due to the small number of replicate plots for each rate tested, these differences were not statistically different; however, if the data for all plots treated with Vapam (all three rates) are combined and analyzed, then a statistically significant reduction of 44% in the incidence of Fusarium wilt occurred after applying Vapam at rates ranging from 30 to 60 gal per acre (Table 2). Further work is needed to attempt to increase the reduction of disease recorded this past year. Refinements in our solarization technique as well as application methods for Vapam may increase the efficacy of these tools in reducing the incidence and severity of Fusarium wilt of lettuce.

Table 1. Severity of Fusarium wilt and development of lettuce plants grown in soil subjected to flooding or solarization from 15 to 60 days [1]

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Soil treatment [2]	Severity of Fusarium wilt symptoms [3]		Fresh weight of plant (g)	
	Foliar rating	Root rating	Top	Roots
Nontreated soil	**1.9 a** [4]	**2.0 a**	**80 e**	**8.3 c**
Flood - 15 days	1.3 b	1.3 b	121 bcd	9.0 bc
Flood - 30 days	1.1 b	1.2 b	106 d	7.8 c
Flood - 45 days	1.0 b	1.0 b	112 cd	9.6 bc
Flood - 60 days	1.0 b	1.1 b	114 cd	6.4 c
Solarized - 15 days	1.0 b	1.0 b	143 ab	17.5 a
Solarized - 30 days	1.1 b	1.1 b	134 abc	18.0 a
Solarized - 45 days	1.0 b	1.0 b	142 ab	17.3 a
Solarized - 60 days	1.0 b	1.0 b	156 a	13.8 ab

1. Data presented are from lettuce plants grown in soil naturally infested with *Fusarium oxysporum* f. sp. *lactucae* that was subjected to flooding or solarization for 15, 30, 45 or 60 days. Nontreated soil was maintained in microplots but not irrigated, flooded, or solarized. Soil samples used in this lettuce bioassay were collected at a depth of 1 to 3 inches within microplots. Similar results (not presented) were achieved from soil collected at a depth of 8 to 10 inches within microplots.
2. The range and mean soil temperature values at the 2-inch depth during the entire soil treatment period
   (Jul 13 to Sep 10, 2004) were as follows:
   Nontreated soil: range, 68 to 131EF (20 to 55EC); mean 104EF (40EC).
   Flooded soil: range, 68 to 107EF (20 to 42EC); mean 91EF (33EC).
   Solarized soil: range, 71 to 142EF (22 to 61EC); mean 113EF (45EC).
3. Rating scale for Fusarium wilt symptoms on lettuce plants. **Foliar symptoms**: 1 = no apparent disease;
   2 = slight to moderate stunting; 3 = severe stunting and yellowing; 4 = dead plant. **Tap root (cortex) symptoms:** 1 = No discoloration; 2 = slight to moderate yellowing; 3 = slight to moderate red streaking;
   4 = necrotic root tissue.
4. Values in each column followed by a different letter are significantly different according to the Least Significant Difference test (LSD) at (*P* = 0.05).

Table 2. Effect of preplant treatments of soil beds with solarization or three different rates of Vapam on subsequent incidence of Fusarium wilt on lettuce.

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Treatment	Percent reduction in disease
Solarization	42 **
Vapam @ 30 gal per acre	38 n.s.
Vapam @ 45 gal per acre	50 n.s.
Vapam @ 60 gal per acre	45 n.s.
Average of all Vapam rates	44 **

**	Significant statistical reduction in disease compared to nontreated beds (*P* # 0.01)
n.s.	Not statistically different than nontreated beds